Digital periarterial sympathectomy in the management of post-traumatic Raynaud syndrome

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Objective: **Among Basque handball players, the repeated impact of a ball on the palms of their hands hundreds of thousands of times throughout their sporting careers produces Raynaud syndrome. Treating this patient group is complex. Our objective was to assess the efficacy of digital periarterial sympathectomy in this patient group.**

Methods: **The study included all of the federated amateur and professional Basque handball patients who presented with Raynaud syndrome assessed in the vascular surgery service between January 2005 and December 2012. The postoperative assessment included a physical examination, basal photoplethysmography and photoplethysmography after heat hyperemia, and arteriography or magnetic resonance angiography.**

Results: **All 182 digital periarterial sympathectomies in the 114 fingers of 60 patients were in Porter functional class III or IV. All patients were discharged within the first 48 hours. Follow-up results, with a mean of 2 years ± 5 months, were 100%. All patients presented immediate pain remission, recovery of comfort, normal nail growth, rapid healing of all ulcers, distal anhidrosis, and return to active sport participation. The results remain steady in 58 patients (93.5%). Mean time until return to sports activity was 9.95 ± 1.61 weeks.**

Conclusions: **Digital periarterial sympathectomy is a simple, relatively nonaggressive technique without adverse side effects and with excellent medium-term results. In patients with Raynaud syndrome refractory to medical treatment and with threat to the viability of one or several fingers, digital periarterial sympathectomy can be the first treatment option, especially in cases of arteritis associated with very severe spasms. (J Vasc Surg 2016;63:459-65.)**

Among Basque handball players, the repeated impact of a ball on the palms of their hands can cause post-traumatic Raynaud syndrome. The severity of the disease varies from isolated bouts of vasospasm, triggered by phenomena such as the cold or emotional stress, to the critical stages of ischemia with constant pain, necrosis, or gangrene in the fingers. The effects are similar to those produced in cases of hemorheologic and histologic periarterial vascular affectations.[1,2]

The game of Basque handball produces a repeated impact on the palm of the hand (hundreds of times during a competition and hundreds of thousands of times over a sports career) from a very hard ball with a diameter of 62 mm, weighing 95 to 107 grams, whose speed can reach 120 km/h. The punch of the ball produces a hand vasospasm that can affect all fingers except the thumb.[3]

Digital periarterial sympathectomy has shown satisfactory results in cases of chronic digital ischemia secondary to repetition injuries caused by the job or sports, freezing, thromboangiitis obliterans, and collagen diseases.[4-12] We present our results of digital periarterial sympathectomy in the treatment of Raynaud syndrome in Basque handball players who compete in official tournament games.

METHODS

This study was conducted according to the Declaration of Helsinki and Good Clinical Practice and was approved by the Institutional Review Board.

Patients

A prospective cohort study was designed. The patients gave their written consent to store their data anonymously in the hospital database for scientific purposes, in accordance with Spanish regulations.

Between January 2005 and December 2012, digital periarterial sympathectomy treatment was given in a single center to 60 male patients with a mean age of 23.2 ± 4.4 years (range, 16-37 years). Of these, 38 patients presented with Porter classification grade III ischemia (cold intolerance, atrophy, umbilication and ulceration of the fingertip) and 22 with grade IV (digital gangrene; Fig 1).[13] The study

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Fig 1. Fingers with Porter classification grade IV ischemia.

excluded 11 patients because of aneurysm of the cubital artery, post-traumatic occlusion of the radial artery, costovertebral outlet syndrome, history of cervicothoracic sympathectomy, or job-related exposure to cold.

Digital periarterial sympathectomy was indicated for patients with Porter grade III or IV ischemia after 4 to 6 weeks of optimal pharmaceutical treatment with purine derivatives (600 mg/d pentoxifylline), calcium antagonists (2.5 mg/d lacidipine), and analgesic treatment that failed to control the pain (preventing sleep) or in patients with a high risk of losing one or more fingers, or both.[11]

A total of 182 digital periarterial sympathectomies were performed on 114 fingers; these were bilateral on 68 fingers with grade III or IV ischemia and unilateral on 46 fingers with grade II ischemia adjacent to the previously mentioned fingers. Mean time of sports activity was 13.7 ± 4.3 years (range, 6-24 years). Patient distribution by category was professionals, 18 (30%); senior, 22 (37%); under-22 amateurs, 12 (20%); and young people, 8 (13%).

Based on their position on the handball court, 24 patients were *zagueros* (back-row players), and 36 were *delanteros* (front players). The right hand was dominant in 40 patients and the left in 20. Ischemia sometimes appeared in the nondominant hand. Two right-dominant patients presented with ischemia in the fingers of the left hand, and three left-dominant players presented ischemia in the fingers of the right hand.

Only one finger was affected in 23 patients, two were involved in 20, and 3 in 17 (Fig 1). Among those with a single finger, the problem was the second finger in 2 patients (1 patient with ischemia grade III and 1 with ischemia grade IV), the third finger in 18 (9 with ischemia grade III and 9 with ischemia grade IV), and the fourth finger in 3 (2 with ischemia grade III and 1 with ischemia grade IV).

When two fingers were affected, they were the second and third in 12 patients, the third and fourth in 5, and the fourth and fifth in 3. In all cases, a bilateral digital periarterial sympathectomy was indicated for the most severely damaged finger, and for the other, unilateral surgery of the arterial branch nearest the most seriously affected finger (the radial in 7 and cubital in 13). If three fingers were affected, in four patients they were the second, third, and fourth, and in one patient, the third, fourth, and fifth.

In 12 patients, bilateral surgery was performed on the central finger, with unilateral surgery of the attached artery branch in the two adjacent fingers. Surgery in two patients was bilateral in two fingers and unilateral in one adjacent finger. In three patients, the surgery was bilateral in the three fingers.

Surgical technique

Surgical treatment was performed under locoregional anesthesia in 26 patients (43%) and with general anesthesia in 34 (57%). Surgical protocol, with magnifying loops of ×5.5, but without using an ischemia cuff, was as follows[14,15] (Fig 2):

1. Longitudinal incision of ~2 cm in the radial or ulnar of the proximal phalanges of the fingers, always on the edge of the volar side of the finger, which is the side that receives the direct impact of the ball in handball.
2. Exposure and control of the digital vascular-nerve bundle, artery, and collateral digital nerves.
3. Section of the neurovascular branches that communicate between the artery and the collateral digital nerves. The artery and the nerve are controlled separately.
4. Stripping of the vascular adventitial sheath of the collateral digital artery along the broadest possible path between the interdigital space and the proximal interphalangeal joint.
5. Careful hemostasis using gentle pressure, without electrocoagulation.
6. Single-layer interrupted suture with 4-0 nonabsorbable material. Surgical clips were never used.
7. When trophic disorders or fingertip ulcers were present, curettage or excision of the necrotic tissue, or both, was performed.
8. Application of medium-level compressive dressing.

Study method

Clinical history and vascular examination were used to diagnose the condition. Palpation of the distal pulses and the Allen test ruled out cubital and radial artery obstruction. Maneuvers of the thoracic outlet area ruled out the presence of a costovertebral outlet syndrome. A complete blood test analysis, including C-reactive protein, total protein test, antinuclear antibodies, cryoglobulins, and rheumatoid factor, was conducted to diagnose Raynaud disease and rule out other connective tissue diseases. Digital periarterial sympathectomy results were assessed by pain remission, skin rewarming, integument dryness, normalization of nail growth, rapid healing of digital ulcers,

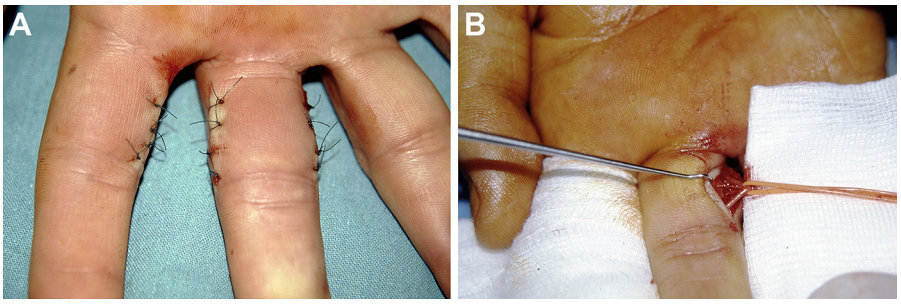

Fig 2. A, Aspect of the incisions in the fingers. **B,** Section of the neurovascular communicating branches and stripping the vascular adventitial sheath.

disappearance of cold intolerance, and return to normal sporting activity.

Doppler and photoplethysmography. All patients underwent a study with a vascular automated interactive FLOSCOPE ULTRA (Quermed, Minneapolis, Minn), which included the two-way Doppler module and photoplethysmography (PPG) with light-emitting diode. The PPG curves were classified according to the Boccalon scheme, taken at rest after a thermal hyperemia test (immersion of the hands in hot water at 60°C for 5 minutes), which made it possible to differentiate between vasospasm and obstruction conditions.[1] Periarterial sympathectomy was only indicated if the PPG wave showed no alterations after the hyperemia test. No thermal hyperemia tests were conducted postoperatively.

Two-way Doppler ultrasound with an 8-MHz probe was used to study the permeability of the axillary, humeral, radial, and cubital arteries. We did not perform this study on the fingers of the Basque handball players with arterial lesions because of the errors it produces: (1) the ambient temperature can affect the results, (2) at normal temperature, a spasm can suppress the signal, and (3) the 8-MHz probe may capture a permeable branch of an obstructed collateral artery, giving a false negative.

Arteriography and magnetic resonance angiography. The first nine patients received an arteriography using a Politrom angiography system (Siemens AG, Munich, Germany). The approach was a direct puncture of the femoral artery and introduction of a 4F catheter to the distal end of the humeral artery. With maximum amplification, two X-ray sessions with digital subtraction technique were performed, using 20 mL of nonionic contrast (5 mL/s in each session): the first with a sequence of two images per second for 10 to 15 seconds and the second with the same parameters, after slow perfusion of 25 mg of tolazoline for 2 minutes and after a 1-minute delay to achieve optimal distal perfusion. We abandoned this technique when we realized that that the images of arterial lesions of the hand, collateral circulation, and distal bed were very similar in all cases and were useless for indicating and planning surgical treatment.

Although magnetic resonance angiography (MRA) is less precise, it replaced arteriography because it enabled us to diagnose the less aggressive obstructions of smaller arteries. The MRA was done with a Signa 1.5 Tesla scanner (GE, Milwaukee, Wisc). The wrist Angiormin technique was applied, with a circular surface spool, initially using fast spin-echo and short-tau inversion recovery sequences, and three-dimensional gradient echo interleaved and time-resolved imaging of contrast kinetics, after administering Gadovist (Bayer, Newbury, United Kingdom) paramagnetic contrast (1 mL/kg and 0.8 mL/s) and maximum intensity projection reconstruction, ensuring the proper acquisition of images with very rapid blood flow.

RESULTS

All patients had vasospasm and obstruction of the collateral digital arteries. The clinical presentations with Porter grade III and IV ischemia were constant distal phalange pain resistant to all types of analgesics, intolerance to cold, atrophy, umbilication, and ulceration of the distal fingertip, and signs of necrosis in the patients in grade IV.[13] The PPG-photo studies revealed (Fig 3):

1. The waves were Boccalon classification types d and e, which showed a poorly compensated obliteration.[1]
2. The PPG photo wave in the preoperative period remained unchanged after the thermal hyperemia test, which replaced the Nielsen and Lassen[16] occlusive digital hyperemia test.
3. In the postoperative controls 3 months after the segmental digital sympathectomy, compensation waves due to the provoked distal vasodilatation were observed.

Although clinical improvement was immediate, the increase in amplitude of the PPG wave was not observed until the third month after surgery.

The arteriography and MRA revealed (Fig 4):

1. The arterial lesions are always more severe than what could be foreseen from the patient anamnesis and physical examination.
2. All of the arterial lesions observed were clearly limited.

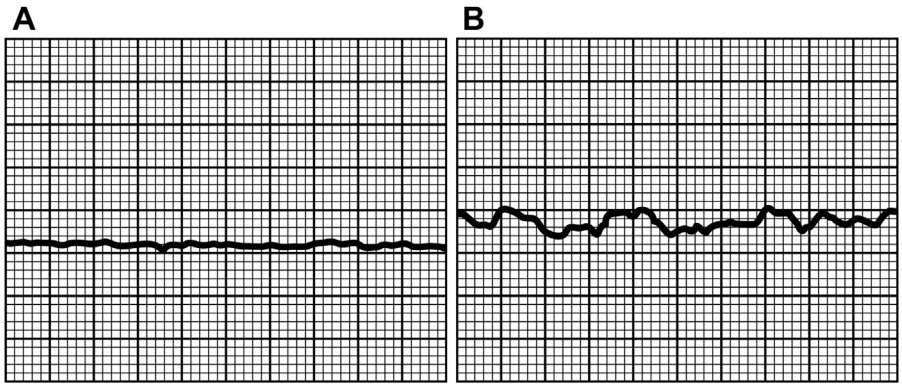

Fig 3. A, Basal photoplethysmography (PPG) of Raynaud syndrome in stage III of the third finger of the right hand shows type e Boccalon severe ischemia curve. **B,** PPG of the same finger 3 months after digital periarterial sympathectomy shows type c Boccalon curve, well compensated arterial obstruction.

Fig 4. Arteriography (arterial lesions).

3. The occlusive lesions were located in the fingers, which presented trophic changes.
4. Fingers in grade II had segmental lesions of the collateral branch adjacent to the finger with ischemia in grade III or IV.
5. The collateral arteries were injured at three different levels: in the interdigital spaces (coinciding with the origin of the collateral arteries), near the proximal interphalangeal joints, and in the middle area of the second phalanges.

During the operations did we not find a hematoma compressing the artery from the adventitia.

All patients were discharged from the hospital within the first 48 hours after surgery. With a mean follow-up time of 24 ± 5 months (range, 18-45 months), all patients had immediate pain remission, recovery of comfort, normal nail growth, quick ulcer healing, distal anhidrosis, and return to active sports participation. The results have remained stable, without recurrence, in 58 patients (93%). Two patients presented with sporadic episodes of intolerance to cold during the winter, which required medical treatment.

The complications included 2-week-long distal paresthesias in eight patients, relating to the manipulation of the collateral digital nerves during the operation, and intolerance to cold in four patients (7%), two of whom required drug treatment during winter. The number of fingers involved influenced the appearance of complications: the more fingers affected, the larger the number of complications ($P < .009$). The incidence of complications was not related to age, time of sporting activity, position occupied on the handball court, and the degree of ischemia.

All 60 patients returned to their sporting activity 10.0 ± 1.6 weeks (range, 8.57-13.42 weeks) after the digital periarterial sympathectomy. The time of return was not related to age, period of sporting activity, and position on the handball court. The time of return to work was associated with the number of fingers involved, the presence of segmental digital sympathectomy complications, and the severity of the ischemia. The number of fingers affected was related to the period of return ($P < .001$). The greater the number of fingers affected, the greater the time until return: one finger, 8.8 ± 1.0 weeks; two fingers, 10.2 ± 1.4 weeks; three fingers, 11.4 ± 1.4 weeks. The occurrence of complications was negatively associated with the time until return ($P < .02$). The mean time until return was 9.7 ± 1.4 weeks in patients who had no complications and 10.9 ± 1.9 weeks in those who had complications. The degree of ischemia in the most severely affected finger negatively influenced the time until returning to

sport ($P < .001$): 9.3 ± 1.3 weeks in ischemia grade III and 10.8 ± 1.6 weeks in ischemia grade IV.

DISCUSSION

Basque handball, various forms of which have been spreading around the world, has been a demonstration game at the Olympics, and since 1952, a world championship is held every 4 years. The International Federation of Basque Handball (*Federación Internacional de Pelota Vasca* [FIPV]) currently controls ~100,000 licenses, belonging to the 36 associated federations in Europe (Belgium, Spain, France, Greece, Holland, Italy, the Netherlands, Poland, and Sweden), North and South America (Argentina, Bolivia, Brazil, Canada, Chile, Colombia, Costa Rica, Cuba, Ecuador, El Salvador, the United States, Guatemala, Mexico, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, Dominican Republic, Uruguay, and Venezuela), Asia (the Philippines and India), and Africa (Guinea, Morocco, and Togo). Approximately 50% of players belong to the group of Basque handball players.

Raynaud syndrome develops in the hands of Basque handball players as a result of the repeated impact of the ball in the palms, hundreds of thousands of times throughout their sporting careers. Our study group showed that 57% of those who play the game, 77% of federated players in the senior category, and 88% of professionals injure the arteries in the hand and fingers.[15] Players normally hit the ball with the part of the hand corresponding to the metacarpal-phalangeal joint of the middle (third) finger, which is usually the most-affected finger. The slight displacement of the area used by the front player toward the metacarpal-phalangeal joint of the index (second) finger and of the rear player toward the ring (fourth) finger explains the signs of ischemia, albeit less severe, in the second and fourth fingers.

Conventional angiography and MRA provide anatomic information about the location and extension of the occlusive lesions, the severity of which has always been greater than what can be foreseen by the patients' signs and symptoms. The greater the regularity, duration, and intensity of the sports activity, the more evident the pathologic results obtained from the examinations.

Regardless of the involvement of the collateral digital arteries from the direct aggression of the handball, progressively harder and faster, we have been able to demonstrate the existence of other mechanisms that produce post-traumatic Raynaud syndrome derived from the placement of new protection systems used by the Basque handball players. Because the protection devices for the metacarpal-phalangeal joints are supported by the intermetacarpal spaces, they provoke a spasm and later thrombosis in the bifurcation of the digital arteries, as revealed in the angiographic images obtained and the sporadic observation of Raynaud syndrome that affected the radial half of a finger and the cubital of an adjacent finger.[17] The protections placed in the palm of the proximal phalanges are strengthened by adhesive tape strips that hug the root of the finger.[17] The progressive edema that the game provokes in the fingers makes the tape (nonstretchable material) dig in, and as it constricts the roots of the fingers, stimulates the appearance of artery spasms that cause Raynaud syndrome (Fig 5).

Fig 5. Types of protection used by Basque handball players.

The special occupational and socioeconomic circumstances of the Basque handball players make the general principal of identifying and eliminating the cause of Raynaud syndrome more difficult. General care is aimed at avoiding precipitating or triggering factors. If diagnosis is rapid and the patient reports only brief, sporadic flare-ups of Raynaud, pentoxifylline is the treatment of choice. Patients in grade II have been treated with calcium channel blockers, alone or combined with pentoxifylline. Prostaglandin E1, prostacyclin, and derivatives require intra-artery or intravenous administration, and no randomized studies with post-traumatic digital ischemia have been published.[18] Spinal cord stimulation regulates microcirculation and has shown its efficacy in Raynaud syndrome, but implanting an epidural electrode connected to a subcutaneous generator was rejected by all of the athletes in our series to whom this technique was proposed.[19,20] When medical treatment fails and digital ischemia makes normal sports activity impossible, digital periarterial sympathectomy is indicated.

Cervical-thoracic sympathectomy was a routine technique and the treatment of choice for severe upper limb ischemia. In the earliest publications, the symptoms that had indicated the surgery frequently persisted, the beneficial effects were often transitory, and the symptoms reappeared as soon as the activity that caused them was reinitiated.[21] Lowel et al[22] reported the experience of the Mayo Clinic in which 3219 patients with Raynaud syndrome were treated over a 10-year, but only 20 were surgically treated in that time. Monti et al[23] describes the great disparity in the results obtained and the great number of undesired adverse effects, such as post-thoracotomy neuralgia from surgical manipulation of the intercostals nerves, alterations in perspiration control with hyperhidrosis in some areas and anhidrosis in others, recovery of sympathetic activity, Claude Bernard-Horner syndrome, and difficulties in using contact lenses.

Thoracic sympathectomy using a thoracoscopic approach, which reduces morbidity, mean hospital stay, and the period until return to the patient's normal activity, has made open surgery techniques obsolete in the treatment of hyperhidrosis.[24] However, recurrences persist in the treatment of Raynaud syndrome. Two patients were excluded from our study because they had received thoracoscopy sympathectomy without any benefit 6 months before being treated with digital periarterial sympathectomy.

The history of digital periarterial sympathectomy began in 1889, when Jabulay[25] removed the arterial adventitia for the treatment of trophic limb ulcers. In 1913, Leriche,[26] who named the surgical intervention performed by Jabulay "periarterial sympathectomy," proposed it as a treatment for a variety of circulatory disorders of the extremities. Interrupting the pathways that innervated the limb blood vessels and excising the postganglionic fibers that surrounded the femoral and humeral arteries produced an effect that was, besides unpredictable, transitory. In 1990, Pick[27] demonstrated that sympathetic innervation of the fingers happened in a segmental and phased manner because the fibers of the cervical-thoracic sympathetic branch were bridged by sympathetic fibers from the sinuvertebral nerve, the brachial plexus, and the Kunz nerve.

In 1980, Flatt[5] was the first to publish a series of eight patients (four men and four women) who, because of presenting a chronic digital ischemia from freezing, smashing, scleroderma, and Raynaud disease, had been treated with digital periarterial sympathectomy. In the same decade, Egoff et al,[6] Wilgis,[4] and Pointel et al[28] reported 9, 3, and 10 patients, respectively, with chronic digital ischemia treated with digital periarterial sympathectomy. The results were satisfactory, even though patients with chronic digital ischemia secondary to job-related repetition trauma, freezing, Buerger disease, and collagenosis had been included in the three series. In 1991, Gomis et al[7] published excellent results for 30 digital periarterial sympathectomies in 24 fingers with chronic digital ischemia from Raynaud syndrome and Buerger disease. In 2012, Wasserman et al[29] demonstrated the benefits of digital periarterial sympathectomy for the Raynaud phenomenon with digital ulcers associated with a systemic sclerosis, despite extreme environmental stress such as exposure to cold and hypoxia.

Our series consists of 182 digital periarterial sympathectomies performed on 114 ischemic fingers belonging to 60 patients with chronic digital ischemia, secondary to repetition trauma due to the sporting activity of Basque handball. During surgery, we found no hematomas that compressed the artery from the adventitia or the exterior of the artery. The aim of the adventitiectomy is to disconnect the nerve endings that carry sympathetic stimuli. The arterial obstruction is caused by an endarteritis that provokes distal vasospasm when secondary thrombosis occurs.

Basque handball is a bilateral sport played with both hands. Most of the digital ischemia occurs in the dominant hand, although the nondominant hand also hits the ball and may be injured. In some cases, the digital periarterial sympathectomy has been conducted bilaterally for the most symptomatic finger. Associated periarterial sympathectomy was conducted where the obstruction of two contiguous digital arteries affected the two collateral arteries of one finger and the radial and cubital branches of the contiguous fingers, with a significant reduction to the amplitude of the PPG waves.

We have more experience in this type of surgical intervention than the sum of all the cases recorded in literature. The absence of surgical complications, the immediate pain remission, the rapid healing of ulcers, and the return to active sporting activity without any recurrences, with a follow-up period of 2 years ± 9 months, justifies the application of digital periarterial sympathectomy for severe digital ischemia.

In patients with a syndrome resistant to medical treatment and with threats to the viability of one or more fingers, digital periarterial sympathectomy—a simple, nonaggressive technique with excellent medium-term results—may be the first therapeutic option, especially in cases of arteritis associated with severe spasm phenomena. In addition to avoiding a mutilating surgery, it permits patients to return to their normal sporting activity (Basque handball) in a maximum of 10 weeks, which represents an especially valuable contribution to the development of this sport.

The primary limitation of this study was its retrospective character, the use of our own criteria for the technical assessment of the injuries, and the impossibility of comparing the results with other studies or other patient groups treated differently.

CONCLUSIONS

Raynaud syndrome develops in the hands of Basque handball players due to the repeated impacts of a ball on the palms. Our group has demonstrated that in this sport, the arteries of the hands and fingers are injured by the repeated impacts to the palm of the hand, with 57% of players being affected, a figure that extends to 88% for professional players.[10] In patients with Raynaud syndrome refractory to medical treatment, whose viability is threatened in one or more fingers, digital periarterial sympathectomy may be the first therapeutic option. It can be especially indicated in cases of arteritis associated with very severe spasm phenomena. Besides avoiding a mutilating surgery, it allows patients to return to their normal sporting activity, Basque handball, in a period no longer than 10 weeks, which represents an important contribution to the development of this sport.

AUTHOR CONTRIBUTIONS

Conception and design: AL, JLR, JBM, JH
Analysis and interpretation: AL, JLR, JBM, JH
Data collection: AL, JH
Writing the article: AL, JLR, JBM, JH
Critical revision of the article: AL, JLR, JBM, JH
Final approval of the article: AL, JLR, JBM, JH
Statistical analysis: JLR
Obtained funding: Not applicable
Overall responsibility: JBM

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